OPERATING INSTRUCTIONS

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TYPE 546-C

AUDIO-FREQUENCY MICROVOLTER

GENERAL ELECTRIC
INSTRUMENTATION & COMMUNICATION
12200 KONA DRIVE
COMPTON, CA 90220

GENERAL RADIO COMPANY

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GENERAL RADIO COMPANY
WEST CONCORD, MASSACHUSETTS, USA

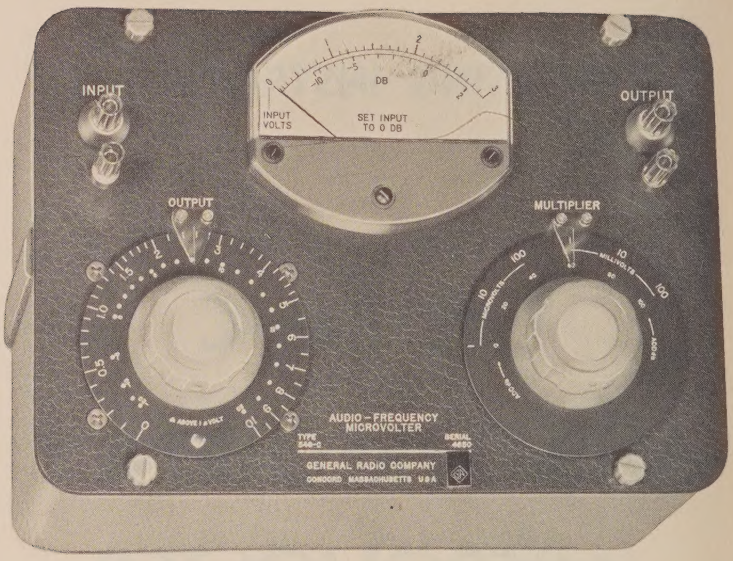

Figure 1.
Panel View, Type 546-C Audio-Frequency Microvolter.

SPECIFICATIONS

Output Voltage Range: 0.5 μv to 1.0 v, with 2.2-v input voltage.

Accuracy: For open-circuit output voltages the calibration is accurate within $\pm(3\% + 0.5\ \mu v)$ for output settings above 1 μv and for all frequencies between 20 and 20,000 cps. For frequencies up to 100 kc the calibration is accurate within $\pm 5\%$ for output settings above 100 μv. These specifications apply only where waveform and temperature errors are negligible (see below).

In calculating ratios of output voltages at a given frequency, the accuracy of any given reading can be considered to be within $\pm(2\% + 0.5\ \mu v)$, at frequencies up to 100,000 cps. At frequencies above 20 kc this accuracy applies only at levels above 100 μv.

Output Impedance: Approximately 600 ohms and is constant with setting within $\pm 5\%$. This impedance is low enough so that no correction on output voltage is necessary for load impedances of the order of 100,000 ohms or more.

Input Impedance: Approximately 600 ohms, substantially independent of output setting on all but the highest multiplier setting.

Waveform Error: Refer to paragraph 3.4.

Temperature Error: Refer to paragraph 3.3.

Power Source: The driving oscillator must be able to supply about 2.2 v across 600 ohms, or about 8 mw.

Terminals: Jack-top binding posts with standard 3/4-in. spacing.

Dimensions: Width 10, height 7-1/8, depth 6-1/8 inches (255 by 180 by 155 mm), over-all.

Net Weight: 6-1/2 lb (3 kg).

TYPE 546-C
AUDIO-FREQUENCY MICROVOLTER

Section 1
INTRODUCTION

1.1 PURPOSE. The Type 546-C Audio-Frequency Microvolter (Figure 1) is a calibrated attenuator or voltage divider which, when used with a suitable oscillator, supplies small, accurately known audio-frequency voltages. Use of the Microvolter converts an oscillator into a standard-signal generator, valuable in such measurements as gain or loss, frequency-response characteristics, overload level, and hum level on amplifiers, networks, and other audio-frequency equipment. The combination of oscillator and Microvolter is also useful in the measurement of the generated voltage of microphones, vibration and phonograph pickups, and other transducers by the insert-voltage method. The Microvolter provides the standardizing voltmeter and the calibrated attenuator necessary to supply accurately known voltages from 0.5 microvolt to 1 volt (open circuit).

1.2 DESCRIPTION.

1.2.1 GENERAL. The Microvolter consists, essentially, of a constant-impedance attenuator and a voltmeter by which the input to the attenuator is standardized. A switch controls the output voltage in decade steps, while an individually calibrated dial provides continuous control over each decade.

1.2.2 CONTROLS. The only controls are the OUTPUT and MULTIPLIER dial-knobs, by means of which the output voltage is set. The OUTPUT control is a continuous rotary knob and dial, the latter calibrated in voltage and in decibels above 1 microvolt. The voltage scale is approximately logarithmic, and the decibel scale approximately linear. The MULTIPLIER control is a six-position rotary switch, whose dial is calibrated in decade steps from 1 microvolt to 100 millivolts. The MULTIPLIER dial is also calibrated in 20-db steps from 0 to 100 db.

A meter on the front panel indicates input in volts and in decibels.

1.2.3 CONNECTIONS. A pair of jack-top binding posts, marked INPUT, provide the connection between the source of audio-frequency voltage and the Microvolter. Another pair of similar binding posts, marked OUTPUT, are the terminals at which the voltage indicated on the dials is available.

1.3 OSCILLATOR REQUIREMENTS. An audio-frequency oscillator must be used to furnish voltage to the Microvolter. Oscillator output requirements are about 2.2 volts across 600 ohms, or about 8 milliwatts. The following General Radio oscillators are suitable:

Type 1210-C Unit R-C Oscillator
Type 1214-A Unit Oscillator
Type 1304-B Beat-Frequency Audio Generator
Type 1307-A Transistor Oscillator
Type 1311-A Audio Oscillator

Section 2
OPERATING PROCEDURE

2.1 NORMAL OPERATION. To provide an audio-frequency output between 0.5 microvolt and 1 volt, proceed as follows:

a. Connect a suitable audio-frequency oscillator (refer to paragraph 1.3) to the INPUT terminals of the Microvolter.

b. Connect the INPUT terminal marked G to the low-potential side of the oscillator, and, if possible, ground this connection.

c. Vary the output of the oscillator until the Microvolter meter indicates 2.2 volts (0 db).

d. Set the OUTPUT and MULTIPLIER dials so that the product of their voltage settings equals the desired output voltage. For highest accuracy, use the portion of the OUTPUT dial between 1.0 and 10. For example, if the desired output voltage is 50 microvolts, set the OUTPUT dial to 5 and the MULTIPLIER dial to 10 MICROVOLTS. If the desired output is 70 millivolts, set the OUTPUT dial to 7 and the MULTIPLIER dial to 10 MILLIVOLTS. Output in terms of decibels above 1 microvolt is denoted by the algebraic sum of the decibel indications on the two dials. Since the reference level is 1 microvolt, almost all decibel readings will be positive throughout the range of the instrument. When the Microvolter is used to supply a 600-ohm load, the output dbm (decibels above 1 milliwatt) equals the output in decibels above 1 microvolt minus 123.8 db.

e. For all ordinary measurement purposes the OUTPUT terminals can be considered the terminals of a 600-ohm generator having the open-circuit terminal voltage indicated by the dial settings.

CAUTION

Never connect the Microvolter OUTPUT terminals across a circuit carrying current, either ac or dc. If the voltage drop at the OUTPUT terminals is over 4 volts, the Microvolter may be permanently damaged, while smaller drops may cause erroneous voltmeter indications.

f. If the output voltage is 100 microvolts or less, use a shielded oscillator and cup-shielded leads.

2.2 USE OF INPUT VOLTAGES LESS THAN 2.2 VOLTS. Since all dial markings are based on an input of 2.2 volts, an input of less than 2.2 volts would produce output voltages less than their indicated values. For instance, if the source is able to supply only 1.1 volts, the output voltage is one-half that indicated on the dials. This simple relationship is expressed:

$$E_o = \frac{E_m E_d}{2.2}$$

where: E_d = voltage indicated on dials
E_m = voltage indicated on meter
E_o = actual output voltage

Also, if reduced power input is unavoidable, the meter indication in decibels can be added algebraically to the dial decibel indications.

Although it might seem that the useful output range of the Microvolter is increased by the above methods, any such increase is achieved at the expense of accuracy.

2.3 D-C VOLTAGES. The Microvolter can be used on direct current if an external meter is used to measure the input voltage.

2.4 MEASUREMENT OF UNKNOWN VOLTAGES.

2.4.1 GENERAL. The Microvolter can be used to measure unknown voltages either directly by means of the Microvolter or by substitution methods. Voltmeter errors (refer to Section 3) must be considered when the Microvolter meter is used to indicate directly voltage applied to the INPUT terminals.

2.4.2 SUBSTITUTION METHOD. In the substitution method, an unknown voltage can be fed into an external, high-impedance meter, and the deflection noted. With the input to the Microvolter at 2.2 volts, the Microvolter output can be fed into the same meter, and the dials adjusted to produce the same deflection. The Microvolter dial settings will then indicate the unknown voltage. If necessary, connect a resistor in series with the external meter to produce a high input impedance.

2.4.3 INSERT-VOLTAGE METHOD. Several measurement techniques using the insert-voltage method can be devised, but the following example will serve to demonstrate the principles involved. Connect the source of the voltage to be measured, the Microvolter, an amplifier, and an external meter as shown in Figure 2. Set the Microvolter dial to zero and supply the unknown voltage to the external meter, noting the deflection. Then, with the unknown remaining in circuit but not supplying any voltage, vary

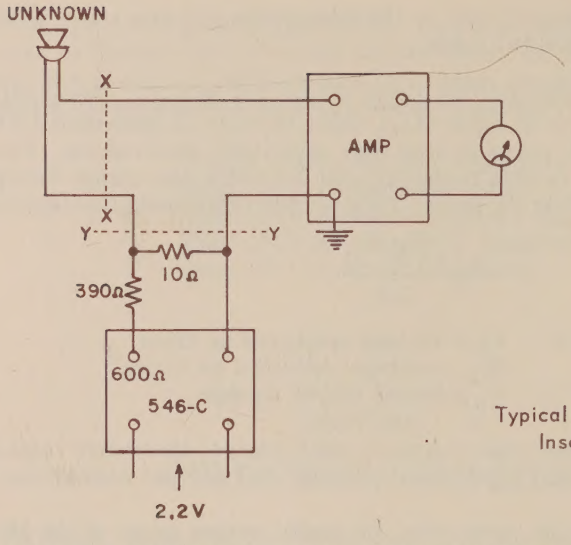

Figure 2.
Typical Measurement Setup Using
Insert-Voltage Method.

the Microvolter dials to produce the same deflection on the external meter as noted before. (The Microvolter should be operating with an input of 2.2 volts.) With the impedance values shown in the diagram, the unknown voltage will be $\frac{10}{600 + 390 + 10}$ or 1/100 of that indicated on the Microvolter dials, since this gives the equivalent open-circuit voltage from the Microvolter across Y-Y in the diagram. The voltage measured is the equivalent open-circuit voltage across X-X in the diagram.

For the circuit arrangement shown in Figure 2, it is essential that the unknown be operated ungrounded, so that the 10-ohm calibration resistor is not shorted by multiple grounds. Any stray capacitance to ground should be kept sufficiently low so that the shunting effect on the 10-ohm resistor is negligible.

Section 3
ERRORS AND CORRECTIONS

3.1 GENERAL. The Microvolter is designed for use without calibration charts or correction curves, and its accuracy is more than sufficient for most measurements. Where extremely high accuracy is required or where the limits of error must be known, the following information should prove helpful.

3.2 OVER-ALL ACCURACY. For output settings above 1 microvolt at frequencies from 20 to 20,000 cps, the open-circuit output-voltage cali-

bration is accurate to within ±(3% + 0.5 microvolt). At frequencies up to 100 kc the calibration is accurate to within ±5% for output settings above 100 microvolts. These specifications apply only when waveform and temperature errors are negligible (refer to paragraphs 3.3 and 3.4).

In calculating ratios of output voltages at a given frequency, the accuracy of any given reading can be considered to be within ±(2% + 0.5 microvolt), at frequencies up to 100 kc. At frequencies above 20 kc this accuracy applies only at output levels above 100 microvolts.

To reduce errors in absolute-voltage values, check the Microvolter against an accurate vacuum-tube voltmeter, such as the General Radio Type 1806-A. Set the Microvolter for an output of 1000 millivolts, and adjust the input voltage to the Microvolter until the vacuum-tube voltmeter indicates 1 volt. Thus, if the input to the Microvolter is maintained, output voltages will be as indicated on the Microvolter dials. This check can be repeated for different frequencies and operating temperatures.

3.3 TEMPERATURE ERROR. Any initial error that may be present in the indicating meter has been compensated for by calibration of the OUTPUT dial. As with all copper-oxide instruments, the meter is somewhat affected by temperature variations. Calibration is correct at 77 degrees F. For room temperatures below this value the correction is -0.0046 volt per degree F. For temperatures above 77 degrees F, the correction is +0.0023 volt per degree F. These corrections should be applied to the normal 2.2-volt meter indication to obtain the correct indication at the operating temperature. For example, if the temperature is 97 degrees F, the correction is +0.0023 (97-77), or 0.046 volt. This correction, added to the standard meter indication of 2.2 volts, gives a corrected meter setting of 2.246 volts. The accuracy of the calibration is independent of temperature when the Microvolter is used as an attenuator or voltage divider.

3.4 WAVEFORM ERROR. The accuracy of the Microvolter as a calibrated attenuator or voltage divider is independent of waveform. However, the absolute accuracy of the output voltage calibration depends on the characteristics of the input copper-oxide rectifier voltmeter, which has a waveform error that depends in turn on both the phase and the magnitude of harmonics present in the input. If the input voltage is not a pure sine wave, the resultant error for absolute measurements can be nearly as great as the percentage of harmonics present. This error can usually be overlooked when the Microvolter is used with ordinary laboratory oscillators. The rectifier-type voltmeter itself introduces some distortion unless the source impedance is very low. With a source impedance of 600 ohms the distortion introduced is about 0.2 percent.

3.5 OUTPUT IMPEDANCE. Since the Microvolter indicates open-circuit voltages, the internal output impedance must be taken into account with low-impedance loads. For loads greater than 100,000 ohms no correction need be made.

Section 4
SERVICE AND MAINTENANCE

4.1 WARRANTY. We warrant that each new instrument sold by us is free from defects in material and workmanship, and that, properly used, it will perform in full accordance with applicable specifications for a period of two years after original shipment. Any instrument or component that is found within the two-year period not to meet these standards after examination by our factory, district office, or authorized repair agency personnel, will be repaired, or, at our option, replaced without charge, except for tubes, or batteries that have given normal service.

4.2 SERVICE. The two-year warranty stated above attests the quality of workmanship in our products. When difficulties do occur, our service engineers will assist in any way possible. If the difficulty cannot be eliminated by use of the following service instructions, please write or phone our Service Department (see rear cover), giving full information of the trouble and of steps taken to remedy it. Be sure to mention the type and serial numbers of the instrument.

Before returning an instrument to General Radio for service, please write to our Service Department or nearest district office, requesting a Returned Material Tag. Use of this tag will ensure proper handling and identification. For instruments not covered by the warranty, a purchase order should be forwarded to avoid unnecessary delay.

4.3 POTENTIOMETER ELECTRICAL NOISE. Occasionally, rotation of the OUTPUT control may cause some electrical noise. This condition can be alleviated if the control is rapidly swept back and forth a few times.

4.4 CALIBRATION PROCEDURE.

4.4.1 TEST SETUP. For a description of the equipment required and the connections necessary for a complete calibration of the Type 546-C Audio-Frequency Microvolter, see Figure 3.

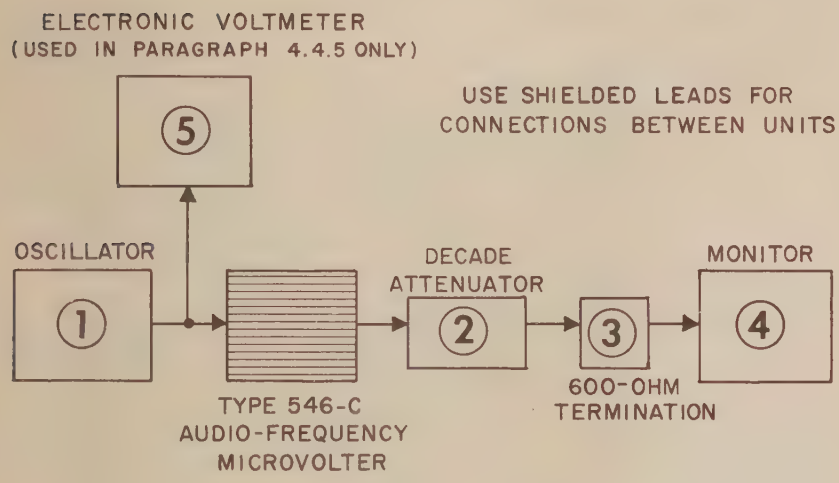

Figure 3. Calibration Test Setup.

① Oscillator — Capable of output signals of 0 to 100 kc, ±5% or better accuracy; 0 to 3 v, rms, into 600Ω. Distortion should be less than 1%, especially if the electronic voltmeter used is peak reading. (See paragraph 3.4 for further details on errors caused by signal distortion). The Type 1210-C Unit R-C Oscillator may be used.

② Decade attenuator — 600-ohm attenuator; 0 to 80 db in 0.1-db steps; ±0.5% or better accuracy. The Type 1450-TB Decade Attenuator may be used.

③ 600-ohm termination — 600-ohm, ±0.5% resistor. The Type 500-G Resistor may be used.

④ Monitor — Capable of monitoring signals of 10 μv to 1 v, rms 1 kc. The Type 1232-A Tuned Amplifier and Null Detector may be used. Accuracy is unimportant except for the first check of paragraph 4.4.3, where the accuracy at 1 v must be within ±0.5%. For this check, either a separate monitor with the necessary accuracy must be used or the original monitor must be calibrated at 1 v.

⑤ Electronic voltmeter — Capable of measuring signals of 2 to 3 v, rms 20 cps to 100 kc. Accuracy is unimportant, but frequency response from 20 cps to 100 kc must be flat. Also, if a peak reading electronic voltmeter is used, the distortion of the oscillator must be less than 1% to avoid measurement errors. (See paragraph 3.4 for further details on errors caused by signal distortion).

4.4.2 METER ACCURACY.

Preliminary settings:

OUTPUT dial	10
MULTIPLIER switch	100 db
Oscillator frequency	1 kc

Meter Accuracy Checks:

Procedure	Type 546-C Input Meter Reading	Decade Attenuator Setting
Set oscillator output amplitude for exactly 2.2 v (0 db) on Type 546-C input meter. Note monitor reading.	2.2 v (0 db)	20 db
For each of these checks, set the oscillator amplitude for the Type 546-C input meter reading listed. Then set the decade attenuator to return the monitor to the reading noted above. At this reading the decade attenuator must be set within the limits given.	2.77 v (+2 db)	22, ±0.3 db
	1.1 v (-6 db)	14, ±0.3 db
	0.7 v (-10 db)	10, ±0.3 db

4.4.3 OUTPUT DIAL ACCURACY.

NOTE

The OUTPUT dial is calibrated and engraved for each individual instrument at the factory.

Preliminary settings:

MULTIPLIER switch	100 db
Oscillator frequency	1 kc
Oscillator amplitude	Set for exactly 2.2 v (0 db) on Type 546-C input meter.

Output Dial Accuracy Checks:

Procedure	OUTPUT Dial Setting	Decade Attenuator Setting
Slip OUTPUT dial on shaft, if necessary, so that a setting of 10 results in a monitor reading of exactly 1 v. The monitor must be calibrated to within ±0.5% at 1 v for this check.	10	0 db
Set monitor sensitivity for any convenient reading. Note this reading.	10	60 db
For each of these checks: 1. Set OUTPUT dial to setting indicated. 2. Maintain 2.2 v (0 db) Type 546-C input meter reading by changing oscillator output amplitude, if necessary. 3. Return monitor to reading noted above by changing decade attenuator setting. The decade attenuator must be within ±0.3 db of the setting given.	9 8 7 6 5 4 3 2 1.5 1 0.5 0.4 0.3 0.2 0.1	59.1 db 58.1 db 56.9 db 55.6 db 54.0 db 52.0 db 49.6 db 46.0 db 44.0 db 40.0 db 34.0 db 32.0 db 29.6 db 26.0 db 20.0 db

4.4.4 MULTIPLIER SWITCH ACCURACY.

Preliminary settings:

OUTPUT dial	10
Oscillator frequency	1 kc
Oscillator amplitude	Set for exactly 2.2 v (0 db) on Type 546-C input meter.

Multiplier Switch Accuracy Checks:

Procedure	MULTIPLIER Dial Setting	Decade Attenuator Setting
Set monitor sensitivity for any convenient reading. Note this reading.	100 db	100 db
For each of these checks:	80 db	80 db
1. Set MULTIPLIER switch to setting indicated.	60 db	60 db
	40 db	40 db
2. Maintain 2.2 v (0 db) Type 546-C input meter reading by changing oscillator output amplitude, if necessary.	20 db	20 db
	0 db	0 db
3. Return monitor to reading noted above by changing decade attenuator setting. The decade attenuator must be within ±0.3 db of the setting given.		

4.4.5 FREQUENCY CHARACTERISTICS.

Preliminary settings:

OUTPUT dial	10
MULTIPLIER switch	100 db
Oscillator frequency	1 kc
Oscillator amplitude	Set for exactly 2.2 v (0 db) on Type 546-C input meter.

C1A adjustment:

Connect an electronic voltmeter to the oscillator output and note the voltmeter reading. Change the oscillator frequency to 100 kc and reset the amplitude, if necessary, to maintain the same voltmeter reading noted above.

Adjust C1A to return the Type 546-C input meter reading to 2.2 v (0 db). Vary the oscillator frequency between 20 cps and 100 kc and keep the output amplitude constant by resetting the amplitude, if necessary, to maintain the same voltmeter reading noted above. The Type 546-C input meter must read 2.2 v, ±0.1 v, at all frequencies between 20 cps and 100 kc.

PARTS LIST

REF DESIG	DESCRIPTION	GR PART NO.
C1A	CAPACITOR, Trimmer, 10-100μμf, 500 dcwv	COT-24
C1B	CAPACITOR, Mica, 100μμf ±10%	COM-20B
M1	METER	MEDS-115
R1	RESISTOR, 400Ω ±0.25%	546-302
R2	RESISTOR, 4 k ±0.25%	
R3	RESISTOR, 400Ω ±0.25%	
R4	RESISTOR, 44.44Ω ±0.25%	546-303
R5	RESISTOR, 356Ω ±0.25%	
R6	RESISTOR, 420-440Ω	546-30
R7	RESISTOR, 200Ω ±5%	
R8	RESISTOR, 1800Ω ±0.25%	546-304
R9	RESISTOR, 178Ω ±0.25%	
R10	RESISTOR, 22.2Ω ±0.5%	
R11	RESISTOR, 178Ω 0.25%	546-305
R12	RESISTOR, 1800Ω ±0.25%	
R13	RESISTOR, 200Ω ±0.25%	
R14	RESISTOR, Film, 417Ω ±1/2%, 1/2w	REF-70
R15	RESISTOR, Wire-wound, 390Ω ±5%, 1/2 w	REW-3C
R16	RESISTOR, Wire-wound, 15Ω ±10%, 1/2 w	REW-3C
R17	RESISTOR, Composition, 12 k ±5%, 1/2 w	REC-20BF
S1	SWITCH	546-321

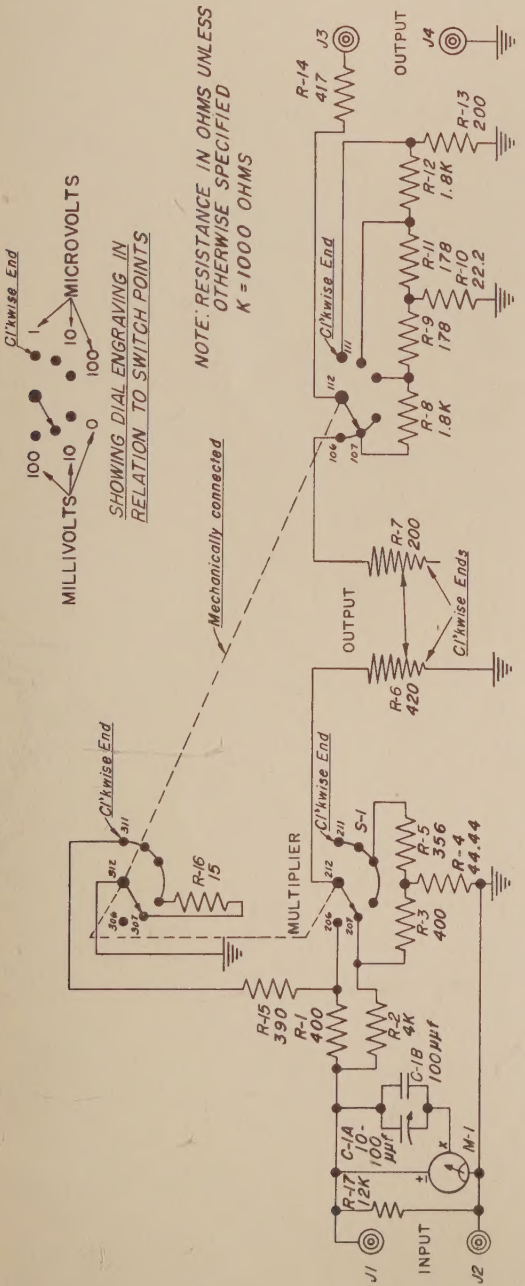

Figure 4. Schematic Diagram for Type 546-C Audio-Frequency Microvolter.

GENERAL RADIO COMPANY

WEST CONCORD, MASSACHUSETTS,* 01781

617 369-4400 617 646-7400

SALES ENGINEERING OFFICES

METROPOLITAN NEW YORK*

Broad Avenue at Linden
Ridgefield, New Jersey, 07657
Telephone N.Y. 212 964-2722
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SYRACUSE

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Telephone 216 886-0150

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Los Angeles, California, 90038
Telephone 213 469-6201

SAN FRANCISCO

1186 Los Altos Avenue
Los Altos, California, 94022
Telephone 415 948-8233

DALLAS

2501-A West Mockingbird Lane
Dallas, Texas, 75235
Telephone 214 FLeetwood 7-4031

TORONTO*

99 Floral Parkway
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Telephone 416 247-2171

MONTREAL BRANCH

Office 395, 1255 Laird Boulevard
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